HYBRID SOLAR CHARGER CUM AUTOMATIC LIGHTING SYSTEM

Date: 13.04.2018

Name: S P CHINHARA

Email ID: spchinhara@rediffmail.com

K-Bank

Confidentiality Statement

The information in the document mentioned is not confidential and have been taken references from various sources as specified.

Abstract

About the Author

Mr. Swayam Prakash Chinhara, Manager (SMS) NINL. He was associated with Electrical and Instrumentation maintenance for 15 years and worked in maintenance at M/s Neelachal Ispat Nigam ltd, Duburi, Odisha, and currently working at Instrumentation maintenance of Steel Melting Shop, NINL since last 5 years.

Intended Readers

Introduction

Now a day efforts have been made by the Government to use solar power everywhere due to scarcity of non-renewable energy sources. Solar cell is manufactured by various reputed companies. The use of solar power is increasing day by day. Even some of the factories are already equipped with solar based power plant. The implementation of solar power plant is also in developmental stage in our plant. The main advantages of the solar power plant is clean power i.e. zero pollution. Apart from that, the main disadvantage of the solar power plant is its high initial installation cost.

The subject presented here will be described in two parts. In Part # 1, the use of solar cell for charging of a battery along with automatic switching up lighting system will be described and in Part # 2, the protection circuit for battery will be presented.

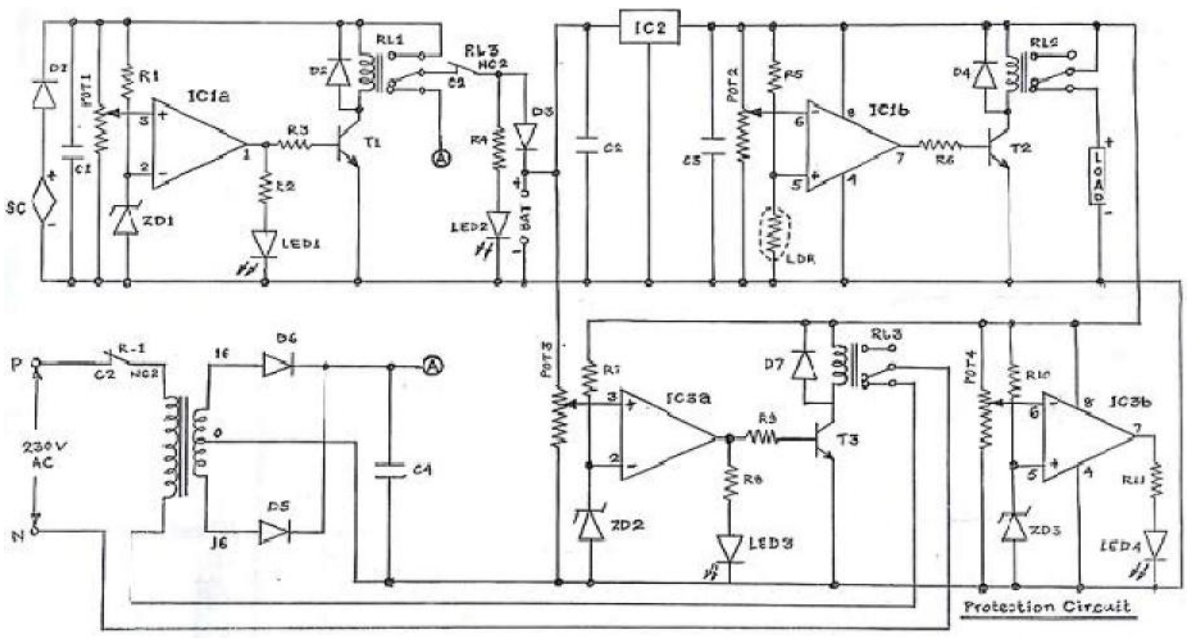
The circuit presented here is a smart hybrid solar charger with automatic switching circuit for light load. The circuit can be used as automatic street lighting system or in any place where the light load is supposed to be switched on during low ambient light. In this hybrid charger the battery used will be charged irrespective of the weather condition. Normally thesolarpanelgets five to six hoursofbright sunlight in a day. If the weather is cloudyorrainy,itaffectsthecharging processandthe batterydoesnot attain full charge. This simple hybrid circuit cansolve theproblem asitcanchargethebatteryusingboth solarpoweraswellasACmains supply. Again this hybrid circuit is able to switch on a light load as per the ambient light intensity from evening to morning or as required by the user. The hybrid circuit presented here is a very low-cost & highly efficient electronic circuit.

Description

PART # 1

Circuit Description:

The circuit presented here is built with a 12V/10W Solar Panel (SC). During daytime the solar panel generates about 18 to 20 volts. When the output of the solar panel is 14 volts and above, the battery used in the circuit will be charged through the solar panel. During absence of sufficient light i.e. during cloudy, rainy, evening or at night time, the output of the solar panel drops below 14 volts. In this situation, the battery will be charged through available 230 volts AC mains supply.



(Figure 1)

Figure 1 shows the circuit diagram for the hybrid solar charging circuit along with automatic switching for the light load in low ambient light. The light load can be used from the battery or may be used directly from the AC source. For energy savings, the battery source must be used for the light load. The circuit is built around 12V/10W solar panel, a dual Operational Amplifier LM 358 (IC1), transistor BC 547 (T1 & T2), 12V Relays (RL1 & RL2), 1 No. of Step down transformer (X1), 2 nos. of potentiometer (POT1) and some few other electronic components.

In bright sunlight, the 12V/10W solar panel provides up to 20 volts DC with 0.6 ampere current. Diode D1 provides reverse polarity protection & capacitor C1 buffers voltage from the solar panel. IC1a is used as a simple voltage comparator. Zener diode ZD1 provides a reference voltage of 11 volts to the inverting input of IC1a while the non-inverting input gets voltage from the solar panel through variable resistor (Trimpot) POT1.

The IC1b is used for switching on/off the light load as per ambient light. The Light Detecting Resistor (LDR) used here works as a light sensor. The resistance of the LDR used will be very high during absence of the light source & goes low when any light source falls on it. The voltage drop across the LDR will be available to the inverting input of IC1b whereas the non-inverting input gets voltage from the battery through the variable resistance POT1.

Components Required:

S/N	SPECIFICATION	QUANTITY	COMPONENT ID
1	Solar Panel, 12V/ 10W	1	SC
2	Diode 1N4007	6	D1, D2, D3, D4, D5, D6
3	Capacitor 470µF/ 35V	1	C1
4	Capacitor 1000µF/ 35V	3	C2, C3, C4
5	Zener Diode 11V/ 1W	1	ZD1
6	Integrated Circuit LM 358	1	IC1 (IC1A, IC1B)
7	Integrated Circuit LM 7812	1	IC2
8	5 mm Green LED	2	LED1, LED2
9	Relay 12V/ 5A, 2 CO	1	RL1
10	Relay 12V/ 5A, 1 CO	1	RL2
11	Transistor BC 547	2	T1, T2
12	Trimpot 10KΩ	1	POT1
13	Potentiometer 10KΩ	1	POT2
14	Transformer 230V AC/ 16-0-16V, 1A	1	X1
15	Resistance 470Ω	1	R1
16	Resistance 1KΩ, ¼ Watt	3	R2, R3, R4
17	Resistance 22KΩ	1	R5
18	Resistance 10KΩ	1	R6
19	Battery 12V/ 7AH	1	BAT

Working:

The working of this hybrid circuit is very simple. When output from the solar panel is 12 volts or more, Zener diode ZD1 conducts & provides 11 volts to the inverting terminal of IC1a. The trim-pot (POT1) is to be so adjusted that when the solar panel is generating 14 volts, the non-inverting input will get a higher voltage than the inverting input. At that junction the output of the Op-amp a (IC1a) will be 1. This will turn on the transistors T1 which will conduct & relay RL1 energizes and the same is indicated by LED1. Thus the battery will be charged from the solar panel through normally open (NO) contact & common (C) contact of the relay. At this situation, the transformer is in OFF condition as the normally closed (NC2) contact is open. LED2 indicates the charging of the battery. Diode D2 is used to protect T1 from the back EMF generated from the relay coil. The diode D3 is used to prevent the discharge of battery current into the circuit.

When the output from the solar panel drops below 14 volts, the output of the Op-amp IC1a turns off & the relay de-energizes. Immediately the transformer X1 will be switched on automatically through the normally closed (NC2) contact & common (C2) contact. Now the battery gets charging current from the transformer based power supply through the normally closed (NC) and the common (C) contact of the relay.

Similarly with the availability of sufficient ambient light source, the LDR offers low resistance across it. Due to low resistance, less voltage will be available to the inverting terminal of IC1b. The voltage at the non-inverting input terminal is fed through a variable resistor POT2. The variable resistance is used to control the energizing/ de-energizing of the relay as per the ambient light source intensity (as per users requirement). With proper POT2 setting the non-inverting input will receive high voltage in comparison to the inverting input of IC1b. For this the output of the Op-amp b (IC1b) will be 1 i.e. turns on which will turn the transistor T2 to conducts & relay RL2 energizes. During night time or during absence of ambient light source, the LDR offers high resistance across its terminals. Due to this, low voltage is available to the non-inverting terminal of IC1B in comparison to its inverting input. At this stage the output of the Op-amp b (IC1b) will be 0 i.e. turns off. Any light load can be connected to the normally open (NC) contact & common (C) contact of the relay so that during night hours the light load will get the power supply from the battery even if the AC supply fails. In this circuit, the light load draws power from the same battery so as to reduce the electricity bill drastically.

PART # 2

Circuit Description:

In this section, the protection circuit for the connected battery will be explained. The lower section of the circuit presented in Figure 1 shows the circuit diagram for protection of the connected battery. The circuit is built around a dual Operational Amplifier LM 358 (IC2), transistor BC 547 (T3), 12V Relay (RL3), 2 nos. of trim-pots (POT3 & POT4) and some few other electronic components.

IC3a is used as a simple voltage comparator. Zener diode ZD2 provides a reference voltage of 9.1 volts to the inverting input of IC3a while the non-inverting input gets voltage directly from the battery terminals through variable resistor (Trim-pot) POT3.

The IC3b is used for switching on an LED4, when the battery terminal voltage will be low.

Components Required:

S/N	SPECIFICATION	QUANTITY	COMPONENT ID
1	Diode 1N4007	1	D7
2	Zener Diode 9.1V/ 1W	2	ZD2, ZD3
3	Integrated Circuit LM 358	1	IC1 (IC1A, IC1B)
4	5 mm Green LED	1	LED3
5	5 mm Red LED	1	LED 4
6	Relay 12V/ 5A, 2 CO	1	RL3
7	Transistor BC 547	1	T3
8	Trimpot 1KΩ	2	POT3, POT4
9	Resistance 470Ω	2	R7, R10
10	Resistance 1KΩ, ¼ Watt	3	R8, R9, R11

Working:

The working of this protection circuit is very simple. Usually when a 12 volt battery gets fully charged, then the available terminal voltage is approximately 13.5 volts. In this situation, the output of the voltage regulator IC i.e. IC2 will be approximately 12 volts. At this point, the zener diode ZD2 conducts & provides 9.1 volts to the inverting terminal of IC3a. The trim-pot (POT3) is to be so adjusted that when the battery is fully charged i.e. the available terminal voltage is 13.5 volts, the non-inverting input will get a higher voltage than the inverting input. At that junction the output of the IC3a will be 1. This will turn on the transistors T1 which will conduct & relay RL3 energizes and the same is indicated by LED3. Thus the charging of the battery will be stopped further from either of the charging circuit i.e. from solar charger or from transformer charger. At this situation, the transformer will be in OFF condition as the normally closed (NC) contact will be open. Diode D7 is used to protect T3 from the back EMF generated from the relay coil.

Again when the battery terminal voltage will drop below 12 volts, the output of the Op-amp IC3a turns off & the relay de-energizes. Immediately the transformer X1 will be switched on automatically through the normally closed (NC) contact & common (C) contact. Now the battery gets charging current from the transformer based power supply. In this situation if sufficient solar power is available, then the battery will be charged through the solar charger.

Similarly when the battery is in load & battery charging power is not available from either of the sources, the voltage to op-amp IC3b is fed from the battery source only. In this situation, the zener diode ZD3 conducts as the voltage available across its terminals is more than 9.1 volts. Thus the input voltage available at the inverting terminal of IC3b is 9.1 volts. The trim-pot POT4 is to be so adjusted that when the terminal voltage of the battery is 11 volts or less, the output of the op-amp IC3b will be high. This situation will be indicated by the LED4 connected at the output of the op-amp IC3b. When the battery terminal voltage will be more than 11 volts, the output of the op-amp IC3b will be low i.e. the LED4 will not light up.

Construction & Testing:

The circuit presented here has been assembled in a general purpose line PCB. For IC LM 358, suitable IC base has to be used to protect the IC from overheating. After connecting all the electronic components, the battery terminal is to be connected & a variable voltage source is to be applied at the solar panel terminals. The voltage from the variable source is to be increased gradually from 0 volts. The trim-pot (POT1) is to be so adjusted that at 14 volts & above, the relay RL1 will energize.

For automatic light load circuit, the LDR is to be covered with hand so that ambient light will not fall on. At this stage, the RL2 de-energizes which in turn switch on the light load. The intensity of the ambient light can be adjusted through the POT2.

Acknowledgement

References